US009429064B2

(12) United States Patent
Nagahama et al.

(10) Patent No.: US 9,429,064 B2
(45) Date of Patent: Aug. 30, 2016

(54) **COOLANT CONTROL VALVE APPARATUS**

(71) Applicant: **MIKUNI CORPORATION**, Tokyo (JP)

(72) Inventors: **Kenichiro Nagahama**, Odawara (JP); **Toru Tsuchiya**, Odawara (JP); **Takumi Oikawa**, Odawara (JP); **Masayuki Daikuhara**, Odawara (JP)

(73) Assignee: **MIKUNI CORPORATION**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/206,613**

(22) Filed: **Mar. 12, 2014**

(65) **Prior Publication Data**

US 2014/0190427 A1 Jul. 10, 2014

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2012/073267, filed on Sep. 12, 2012.

(30) **Foreign Application Priority Data**

Sep. 22, 2011 (JP) 2011-207413

(51) **Int. Cl.**
F01P 7/16 (2006.01)
F01P 11/16 (2006.01)

(52) **U.S. Cl.**
CPC ***F01P 7/16*** (2013.01); ***F01P 11/16*** (2013.01); *F01P 2031/00* (2013.01); *F01P 2060/16* (2013.01); *F01P 2070/02* (2013.01)

(58) **Field of Classification Search**
CPC F01P 7/16; F01P 2007/146; Y10T 137/87788
USPC .... 123/41.08–41.1, 41.15, 198 D
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,964,371 A * 10/1990 Maeda et al. 123/41.1
5,979,373 A 11/1999 Sano

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0890717 A 1/1999
EP 1108867 A 6/2001

(Continued)

OTHER PUBLICATIONS

International Search Report, dated Dec. 18, 2012, issued in corresponding application No. PCT/JP2012/073267.

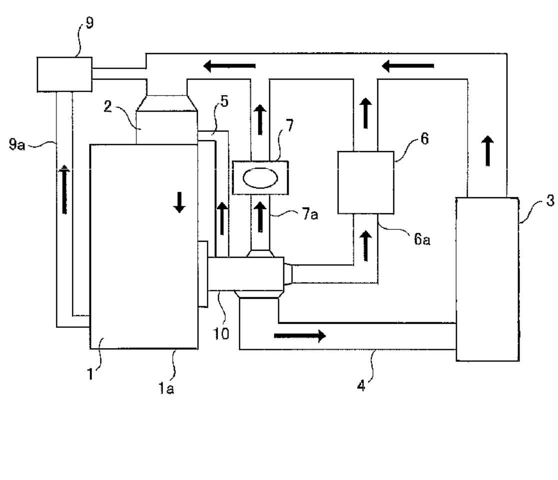
(Continued)

Primary Examiner — Hung Q Nguyen
Assistant Examiner — Kevin Lathers
(74) *Attorney, Agent, or Firm* — Westerman, Hattori, Daniels & Adrian, LLP

(57) **ABSTRACT**

A coolant control valve apparatus **10** includes a main valve **11** which adjusts a flow rate of a coolant in a main channel **4** to control the flow rate of the coolant in the main channel **4**. Further, the coolant control valve apparatus **10** includes a detour channel **67** provided being diverged from the main channel **4** so as to detour the main valve **11**. The coolant control valve apparatus **10** includes a valve main body **41** which opens and closes the detour channel **67** and a temperature detection medium **42** which can open and close the valve main body **41** according to a temperature of the coolant. The temperature detection medium **42** is disposed in the diverging part between the detour channel **67** and the bypass channel **5**.

2 Claims, 5 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

6,109,301	A	8/2000	Pfetzer	
6,371,060	B1	4/2002	Lehmann et al.	
6,539,899	B1 *	4/2003	Piccirilli et al.	123/41.1
2001/0013553	A1	8/2001	Chamot et al.	
2009/0065172	A1	3/2009	Vacca et al.	

FOREIGN PATENT DOCUMENTS

EP	2354607	A1	8/2011
JP	64-066413	A	3/1989
JP	01-106919	A	4/1989
JP	10-077841	A	3/1998
JP	10-089071	A	4/1998
JP	10-317967	A	12/1998
JP	2001-041039	A	2/2001
JP	2009-515106	A	4/2009
JP	2010-528229	A	8/2010
WO	03/042517	A1	5/2003

OTHER PUBLICATIONS

Notice of Reason for Rejection dated Dec. 1, 2015, issued in counterpart Japanese Patent Application No. 2011-207413, with English translation (9 pages).

International Search Report dated Jun. 2, 2003, issued in Application No. PCT/DE02/04022, with English translation (6 pages).

Office Action dated Jan. 12, 2016, issued in counterpart European Patent Application No. 12833165.9-1606 (6 pages).

* cited by examiner

Fig. 1

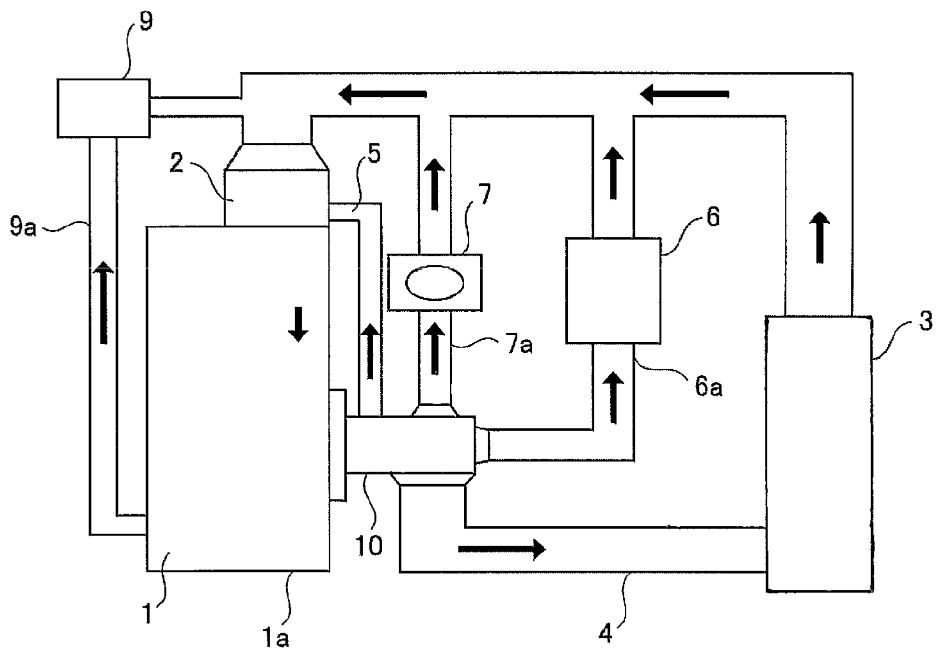


Fig. 2

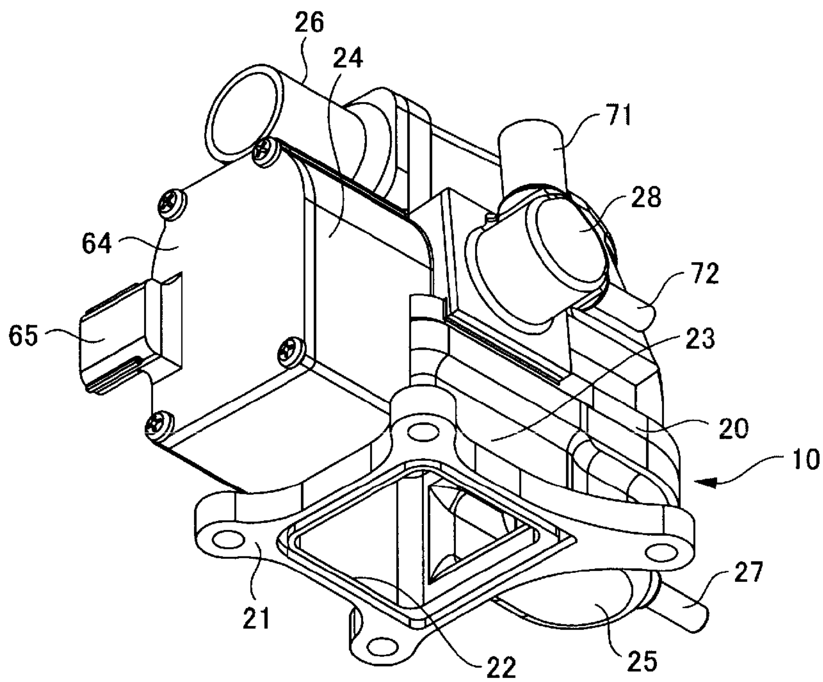

26
24
71
28
64
72
65
23
20
10
27
21
22
25

Fig. 3

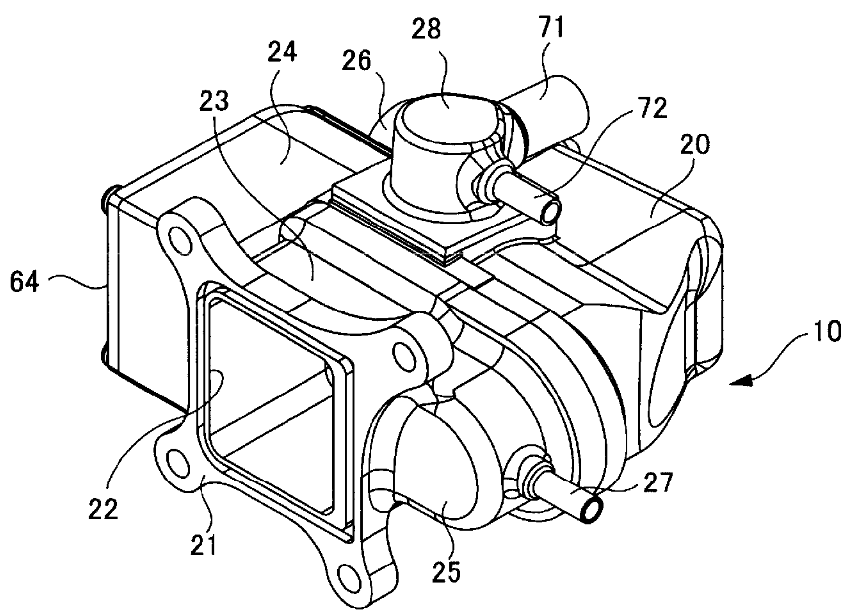

28
71
24
26
23
72
20
64
10
22
27
21
25

Fig. 4

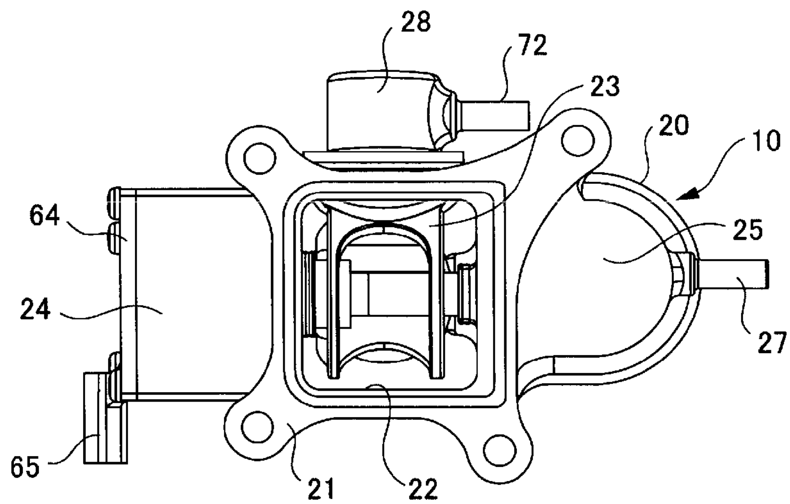

28
72
23
20
10
64
25
24
27
65
21
22

Fig. 5

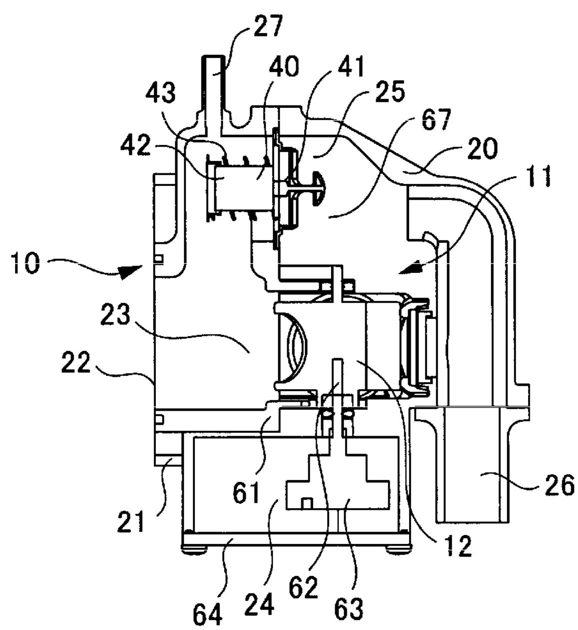

27
40
41
43
25
67
42
20
11
10
23
22
61
21
24
12
26
62
63
64

Fig. 6

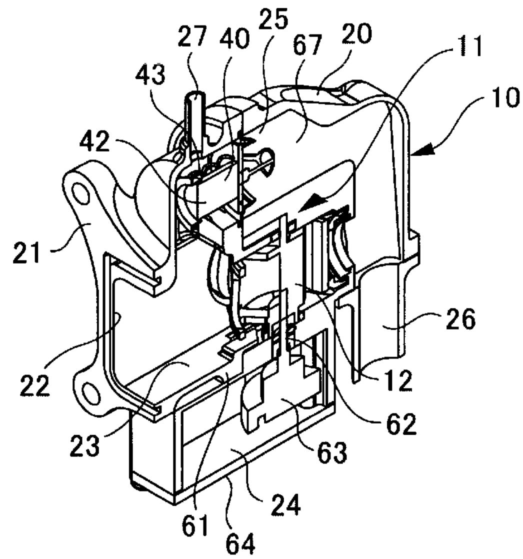

27
40
25
67
20
11
43
10
42
21
26
22
12
62
23
63
24
61
64

Fig. 7

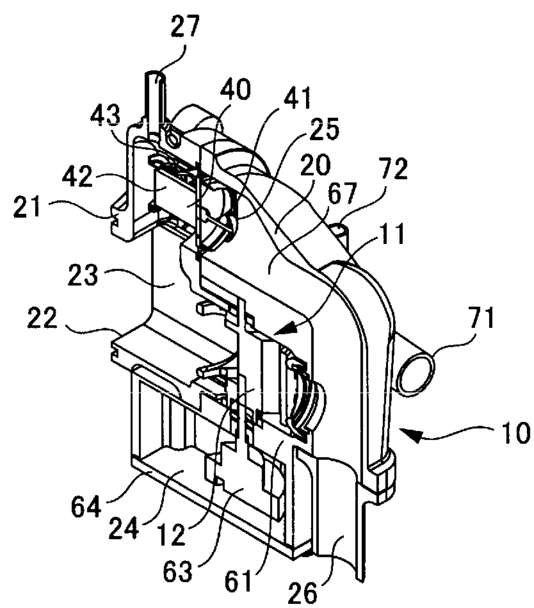

27
40
41
43
25
42
20
72
21
67
11
23
22
71
10
64
24
12
63
61
26

Fig. 8

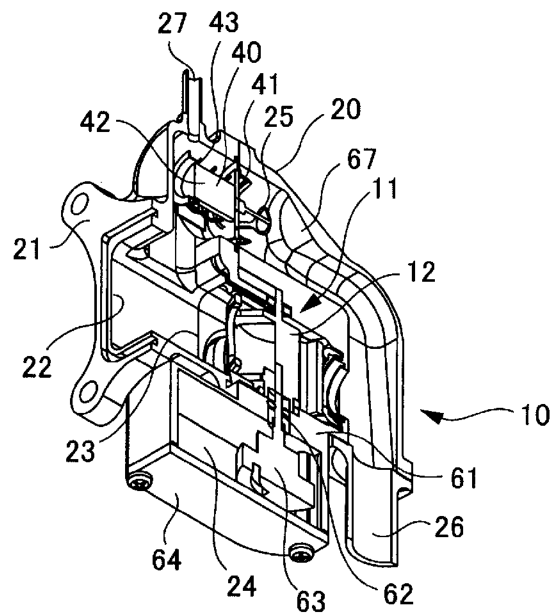
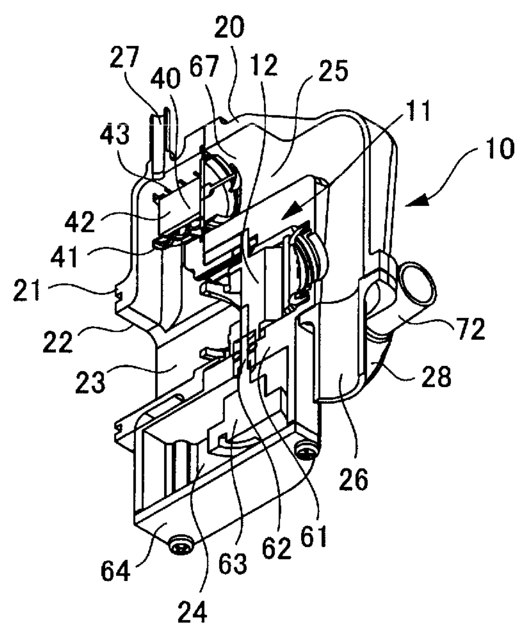

27
43
40
41
42
25
20
67
11
21
12
22
10
23
61
26
64
24
63
62

Fig. 9


20
27
40
67
12
25
11
10
43
42
41
21
72
22
23
28
26
63
62
61
64
24

COOLANT CONTROL VALVE APPARATUS

TECHNICAL FIELD

The present invention relates to a coolant control valve apparatus that controls coolant when water-cooling an engine of a vehicle or the like.

BACKGROUND ART

With regard to an engine of a vehicle such as a car, improvement of a warm-up performance of the engine and improvement of a fuel efficiency by moving the engine at an appropriate temperature and the like have been examined. This was achieved by providing, besides a main passage which circulates coolant between the engine and a radiator, a bypass passage which bypasses the radiator and returns the coolant directly to the engine. A coolant control valve was provided in the main passage, and an opening degree of this coolant control valve was controlled according to a coolant temperature and other values. An amount of the coolant that is flowing in the main passage and cooled off by the radiator was also controlled. For example, at the engine starting or the like, when the coolant temperature is low, warm-up of the engine is promoted by blocking the main passage and returning the coolant from the bypass passage directly to the engine without allowing the coolant to pass through the radiator. Also, for example, for controlling the temperature of the coolant so as to optimize combustion of fuel in the engine after the warm-up, opening and closing (the opening degree) of the coolant control valve is controlled.

As such a coolant control valve, for example, a rotary valve that is driven by a stepping motor or the like, and a thermostatic valve that is moved according to a temperature are examined. Incidentally, as the thermostatic valve, a thermostat, a thermowax or the like that is displaced according to a temperature is adopted, and this displacement according to the temperature opens and closes the valve.

Herein, if, by any chance, the coolant control valve stops its operation in the closed state, the coolant is circulated in the engine via the bypass passage without being cooled off by the radiator, whereby the coolant temperature is increased. If the engine is operated as it is, the engine may become overheated. It has been suggested to circulate the coolant towards the radiator by a valve (other than the coolant control valve) which is provided in a thermal protection device that is operated when the temperature of the coolant is increased when the coolant control valve stops its operation in the closed state or the like (for example, see Patent Literature 1).

That is, the valve that is provided in the thermal protection device works as a fail-safe mechanism. Incidentally, the valve provided in the thermal protection device is a valve which adopts a device that is displaced according to a temperature, for example, a thermostat, a thermowax, shape-memory alloy, a combination of alloy that is melted at a preset temperature with a spring or the like. When the coolant temperature is increased to the preset temperature or higher, the device is displaced according to the temperature so as to open the valve.

CITATION LIST

Patent Literature

Patent Literature 1: JP 2010-528229 W

SUMMARY OF INVENTION

Technical Problem

In Patent Literature 1, when a main control valve is in a closed state, flow of coolant in a passage from an engine to a coolant control valve is stopped, and similarly, flow in a passage of a thermal protection device, diverging from the passage from the engine to a coolant control valve, is also stopped. Thus, a temperature gap is caused between a temperature of the coolant that is circulated in the engine and a temperature detected by the thermal protection device. That is, a long gap of time is caused from a time of increasing the temperature of the coolant in the engine to a time of increasing the temperature of the coolant in a part of the coolant control valve that is in the closed state. Thereby, there occurs a problem in that the temperature of the coolant in the engine cannot be detected appropriately by the thermal protection device.

Also, in the case where there occurs a malfunction in that the coolant control valve cannot be operated and stays in the closed state, the engine may become overheated. In such a situation, the coolant control valve closes the passage of the coolant between the radiator and the engine and the coolant that is flowing out of the engine passes through a bypass passage and then flows into the engine again.

Since the coolant control valve is in the closed state, the coolant is stopped in the part of the coolant control valve, and the temperature of the coolant that is stopped in the part of the coolant control valve is lower than the temperature of the coolant that is circulated in the engine. There is a long gap of time from when the temperature of the coolant in the engine is increased to the time the temperature of the coolant is increased in the part of the coolant control valve that is in the closed state. In the case where a fail-safe valve, provided in the part of the coolant control vale, is moved by the above-described device by displacement according to the temperature, the movement of the fail-safe valve is delayed from the temperature change of the coolant in the engine.

Moreover, if the fail-safe valve is to be controlled according to a temperature setting which includes, in advance, an expected temperature distribution of the coolant in the part of the coolant control valve and in the vicinity thereof so as not to delay the movement of the fail-safe valve, the fail-safe valve may be improperly opened when the fail-safe valve is normally operated because of the thus minimized gap between the control temperature of the coolant control valve and the temperature at which the fail-safe valve is to be opened. That is, if the coolant control valve is closed, the temperature change of the coolant in the part of the coolant control valve is delayed from that in the engine, and if the coolant control valve is opened, the temperature change of the coolant in the part of the coolant control valve is substantially equal to that in the engine. However, if the fail-safe valve is a thermostat type, since the preset temperature for opening and closing the valve cannot be controlled according to the situation, the fail-safe valve cannot sufficiently correspond to the temperature change of the coolant in the part of the coolant control valve according to the state where the coolant control valve is closed or opened.

The present invention is achieved in the light of the above-described problems, and aims to provide a coolant control valve apparatus including a valve that can be opened from a closed state, by appropriately detecting a coolant temperature in an engine while the coolant control valve is closed.

Solution to Problem

To achieve the above object, a coolant control valve apparatus of the present invention controls a flow rate of coolant in a main channel of an engine cooling system a main valve that controls the flow rate of coolant in a main channel of an engine cooling system circulating the coolant between an engine and a radiator; a detour channel diverging from the main channel as a detour for the coolant from the valve to flow away from the main channel; a secondary valve moved independently from the main valve to open and close the detour channel; and a temperature detection medium that drives movement of the secondary valve to open and close the detour channel, and can open and close the secondary valve according to a temperature of the coolant, wherein the temperature detection medium is disposed in a diverging part between the detour channel and a bypass channel of the engine cooling system directing the coolant leaving the engine to bypass the radiator and return to the engine.

In the present invention, by structuring the bypass channel to pass through the temperature detection medium, the temperature detection medium can appropriately detect the temperature of the coolant in the engine even while the valve is closed, and the valve can be opened. If there occurs malfunction to the valve, and the valve cannot be opened from the closed state, the coolant passes through the bypass channel and is not cooled off by the radiator, so that the temperature of the coolant is increased in the engine. Thereby, a temperature of the bypass channel is also increased substantially concurrently.

Herein, to the main channel, the detour channel that detours around the valve (main valve) of the coolant control valve apparatus and the bypass channel that bypasses the radiator are connected. The bypass channel is separated from the detour channel in a part where the detour channel is diverged from the main channel. Thus, the coolant flows at least from the part where the detour channel is diverged from the main channel above the valve to the part of the detour channel where the bypass channel is diverged. Since the temperature detection medium that opens and closes the valve main body according to the change of the temperature is provided in the diverging part between the detour channel and the bypass passage, even in the state where the valve is closed, the coolant that flows in the bypass channel passes through the part of the temperature detection medium.

Therefore, the temperature of the temperature detection medium is increased promptly corresponding to the temperature increase of the coolant in the engine due to the malfunction of the valve. And for example, the valve main body is opened so that the coolant flos into the main channel by detouring around the closed valve, thereby feeding the coolant into the radiator for cooling off. That is, the transmission of the heat caused by the temperature increase in the engine to the temperature detection medium can be prevented from being delayed. Accordingly, further increase of the temperature in the engine before the operation of the valve main body can be suppressed.

Thereby, even if the valve is not opened due to malfunction or the like, it is possible to feed the coolant through the main channel to the radiator by corresponding to the temperature increase of the coolant in the engine, so that the coolant temperature can be decreased. Thus, overheating of the engine can be prevented.

In the above structure of the present invention, it is preferable that the valve is a rotary valve provided with a rotor and includes a controlling means that controls a rotation angle of the rotor. The controlling means includes a power transmission mechanism having a gear train.

According to such a structure, by adopting the rotary-type valve, the flow rate can be adjusted according to the rotation angle of the rotor. Moreover, in order to set the flow rate to be constant or stop the flow, the rotation angle of the rotor is to be maintained. Further, by adopting a gear train as a power transmission mechanism, the rotor can be held at a constant rotation angle. Thus, electric power is not necessary for maintaining the rotation angle of the rotor.

In addition, since the gear train is adopted as the power transmission mechanism, the flow rate can be adjusted by such a simple structure.

Further, in the above structure of the present invention, it is preferable that the temperature detection medium is an on-off valve that opens the valve main body from a closed state according to a change of a detected temperature, and a preset temperature for opening the on-off valve is higher than a preset temperature range for opening the valve.

According to such a structure, in the case of setting the coolant at a high temperature, the coolant temperature can be adjusted by closing the coolant valve and using the temperature detection medium.

Further, in the above structure of the present invention, it is preferable that the temperature detection medium and the valve main body are fail-safe valves that are opened from a closed state according to a change of a detected temperature, and are opened when the temperature of the coolant becomes a predetermined temperature or higher.

According to such a structure, the temperature detection medium and the valve main body are the fail-safe valves, which are operated when the main valve is not operated in the closed state as described above, so that the temperature increase in the engine can be prevented. Thereby, the malfunction caused by the temperature increase in the engine can be prevented.

Further, in the above structure of the present invention, it is preferable that the engine cooling system includes at least one sub channel that circulates the coolant between the engine and a device requiring circulation of the coolant, such as a heater, and the valve can control a flow rate of the coolant in the sub channel.

According to such a structure, the flow rates of the coolant in the plurality of sub channels can be controlled by the one valve, so that cost savings and size reduction can be achieved more than those in a case of adopting a plurality of such valves. Moreover, for controlling to open and close the plurality of channels, for example, the above-described rotary valve is preferably adopted.

Advantageous Effects of Invention

According to the present invention, the coolant control valve apparatus can appropriately detect the temperature of the coolant in the engine, and can open the valve even while the coolant control valve is closed.

Moreover, since the temperature can be detected more appropriately by the temperature detection medium, in the case where the coolant is desired to be set at a high temperature, the temperature can be adjusted also by the temperature detection medium with its opening temperature set to be high. Further, if the valve cannot be opened due to malfunction, since the temperature detection medium of the fail-safe valve detects the temperature increase of the coolant and opens the valve, the valve main body of the fail-safe valve is opened without being delayed from the temperature increase of the coolant, so that the coolant can be feed into the radiator to be cooled off. Therefore, the temperature increase of the coolant due to the malfunction of the valve can be prevented, and the malfunction of the engine or the like caused by the temperature increase can also be prevented.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a cooling circuit diagram illustrating an outline of an engine cooling system that adopts the coolant control valve apparatus of an embodiment of the present invention.

FIG. **2** is a perspective view that illustrates the coolant control valve apparatus.

FIG. **3** is a perspective view that illustrates the coolant control valve apparatus.

FIG. **4** is a perspective view that illustrates the coolant control valve apparatus.

FIG. **5** is a cross-sectional view that illustrates the coolant control valve apparatus.

FIG. **6** is a perspective cross-sectional view that illustrates the coolant control valve apparatus.

FIG. **7** is a perspective cross-sectional view that illustrates the coolant control valve apparatus.

FIG. **8** is a perspective cross-sectional view that illustrates the coolant control valve apparatus.

FIG. **9** is a perspective cross-sectional view that illustrates the coolant control valve apparatus.

DESCRIPTION OF EMBODIMENTS

Hereinafter, an embodiment of the present invention will be described with reference to the accompanying drawings.

As illustrated in FIG. **1**, an engine cooling system that adopts a coolant control valve apparatus **10** of this embodiment includes: the coolant control valve apparatus **10** that is provided communicating with a water jacket **1***a* of an engine **1**; a water pump **2** that is provided communicating with the water jacket **1***a* so as to circulate coolant; a radiator **3** for cooling off the coolant; a main channel **4** for circulating the water from the water jacket **1***a* through the coolant control valve apparatus **10**, the radiator **3**, and the water pump to return the water to the water jacket **1***a* again.

Moreover, in the engine cooling system, the bypass channel **5** is provided to bypass the radiator **3**, that is, the bypass channel **5** is disposed from the coolant control valve apparatus **10** to the water pump **2** without passing through the radiator **3**. Even when the coolant control valve apparatus **10** closes the main channel **4**, the water from the water jacket **1***a* can be circulated by the water pump **2** to pass through the bypass channel **5**. Incidentally, the water pump **2** is driven by driving force of the engine **1**.

Thereby, in the case where a coolant temperature is low at engine starting or the like, by closing the main channel **4** in the coolant control valve apparatus **10**, the coolant is heated by the heat of the engine **1** without being cooled off by the radiator **3**.

Moreover, between the coolant control valve apparatus **10** and the water pump **2**, a sub channel **6***a* and a sub channel **7***a* are provided, in addition to the main channel **4** and the bypass channel **5**. The sub channel **6***a* passes through the heater **6**. The sub channel **7***a* passes through a throttle **7** (a water jacket for a throttle). Incidentally, each of the channels is formed by a pipe, for example.

Also, in a vehicle, exhaust gas recirculation (EGR) may be performed. The EGR is a technique for refluxing a part of exhaust gas to an inlet side so as to allow an engine to breathe the exhaust gas again, whereby a concentration of nitrogen oxide and the like can be reduced.

The EGR valve **9** is for controlling a volume of exhaust gas that is refluxed to the inlet side, and is cooled off by the coolant of the engine. In this embodiment, the water pump **2** and an EGR cooling channel **9***a* that is connected to the water jacket **1***a* are connected to the EGR valve **9** for cooling off. In this embodiment, the EGR cooling channel **9***a* is structured not to pass through the coolant control valve apparatus **10**, but may be structured to pass through the coolant control valve apparatus **10**.

Moreover, the coolant control valve apparatus **10** is provided with a rotary main valve **11**, and according to a rotation angle of a rotor **12** of this main valve **11**, flow rates in the main channel **4** and the two sub channels **6***a* and **7***a* can be changed (the channels can be opened and closed). Further, according to the rotation angle of the rotor **12**, for example, while the main channel **4** is in an opened state, the sub channel **6***a* for the heater **6** can be opened and closed, and an opening degree thereof can be changed. For example, within a range of the rotation angle of the rotor **12** that can maintain the main channel **4** to be in the opened state, a rotation angle that can change the opening degree of the sub channel **6***a* from the closed state to the opened state is included.

For example, the rotor **12** is provided with an opening part that is in communication with the main channel **4** and is long in a circumferential direction. In the state where the coolant can pass through the opening, the rotor **12** can be rotated from a state where the opening for the sub channel **6***a* is in communication with the sub channel **6***a* to a state where the opening is not in communication with the sub channel **6***a*. Incidentally, the rotor **12** may be provided with a plurality of the openings for the main channel **4** to be arranged in the circumferential direction.

Thereby, the above-described structure can realize a state where the main channel **4** is opened, and the sub channel **6***a* may be opened or closed.

As illustrated in FIGS. **2** to **9**, the coolant control valve apparatus **10** of this embodiment includes a casing **20** that is attached to circumference of an opening part, which is not illustrated, of the water jacket **1***a* of the engine **1**. The casing **20** includes: a flange part **21** having an opening **22** in a center part thereof to be in communication with the opening part of the water jacket **1***a*; a principal chamber **23** which has an inner space to be in communication with the opening **22** of the flange part **21** and in which the main valve **11** having the rotor **12** is disposed; a driving chamber **24** in which a driving means that drives to rotate the rotor **12** is disposed; an auxiliary chamber **25** which is in communication with the principal chamber **23** and in which a fail-safe valve (FS valve) **40** is disposed; a main discharge part **26** which is in communication with the principal chamber **23** and the auxiliary chamber **25**, and is connected to the main channel **4**; a bypass discharge part **27** which is in communication with the auxiliary chamber **25**, and is connected to the bypass channel **5** in a state of being diverged from the auxiliary chamber **25**; and a sub discharge part **28** that is connected to the sub channels **6***a* and **7***a*.

In a center of the flange part **21**, the rectangular opening **22** is formed, and the flange part **21** is shaped so that four corner parts of the opening **22** are outwardly extended, and these extended parts are provided with through holes for bolts that fix the flange part **21** to the water jacket **1***a*. Each of the openings **22** is in communication with the inside of the water jacket **1***a* of the engine **1** as described above, and serves as an admission port of the coolant control valve apparatus **10**.

Further, at a circumference of the opening **22** in the flange part **21**, a groove for sealant to be inserted is formed around the opening **22**.

The principal chamber **23** includes an inner space which is provided from the opening **22** of the flange part **21** to a base of the main discharge part **26** that is provided on an opposite side of the opening **22** in the casing **20**, and in this inner space, the main valve **11** that includes the rotor **12** is disposed. The rotor **12** is disposed so as to divide the inner space into the opening **22** side, the main discharge part **26** side, and the sub discharge part **28** side. The rotor **12** includes a plurality of openings and an inner space that is in communication with the openings. The rotation angle of the rotor **12** can switch between: an opened state where the opening **22** side and the main discharge part **26** side are in communication with each other; and a closed state where the opening **22** side and the main discharge part **26** side are not in communication with each other. An opening degree thereof can be adjusted according to the rotation angle of the rotor **12**.

At the same time, the rotation angle of the rotor **12** can also switch between an opened state where the opening **22** side and the sub discharge part **28** side are in communication with each other and a closed state where the opening **22** side and the sub discharge part **28** side are not in communication with each other. An opening degree thereof can be adjusted according to the rotation angle of the rotor **12**.

Incidentally, only one rotor **12** is provided, but as described above, according to the arrangement of the opening that is provided to the rotor **12**, a state where the main channel **4** is opened and the sub channel **6***a* is opened or closed can also be realized. The main valve **11** includes: the rotor **12**; and a rotor containing part which has an inner peripheral surface that is in contact with the outer peripheral surface of the rotor **12**. The rotor containing part also has openings in the inner peripheral surface, where the openings correspond to the respective openings of the rotor **12** and correspond also to the main channel **4**, the sub channel **6***a*, and the sub channel **7***a*. This main valve **11** opens and closes the main channel **4**, and also opens and closes the sub channel **6***a* and the sub channel **7***a*.

The driving chamber **24** is isolated by an isolation wall **61** that is disposed between the driving chamber **24** and the principal chamber **23**. A rotation axis **62** for rotating the rotor **12** penetrates the isolation wall **61** and is connected to the rotor **12** so as to drive to rotate the rotor **12**. In the driving chamber **24**, a gear **63** that is provided together with the rotation axis **62** and is rotated around the rotation axis **62** as a rotation center. A gear attached to a motor that can control its rotation angle (a servomotor, a stepping motor or the like), which is not illustrated, is engaged with the gear **63** directly or indirectly via another gear so as to rotate the gear **63**. That is, a gear train as a power transmission mechanism is arranged between the rotor **12** and the motor. The rotor **12** is driven to be rotated by the motor via the gear train. Since the gear train that is connected to the gear for driving the motor restrains the rotation of the rotor **12**, electric power or the like is not necessary to maintain the rotation angle of the rotor **12**.

The motor is controlled by a controlling device (a controlling means) which is not illustrated. Its rotation angle is controlled, for example, by a coolant temperature that is detected by a sensor and is input into the controlling device, or by a room temperature in a vehicle which is related to the heater **6** or the like. Incidentally, the communication between the opening **22** and the main discharge part **26** comes into the opened state to cool off the coolant by the radiator **3** basically when the coolant temperature reaches a preset temperature or higher. It comes into the closed state when the temperature of the coolant is lower than the preset temperature. But, while being in the opened state, the flow rate of the coolant is also controlled according to the coolant temperature or the like.

Moreover, the driving mechanism for the rotor **12**, such as the motor and the gear **63**, is arranged so as to be stored in the driving chamber **24**. In the driving chamber **24**, a cover **64** that can be opened and closed is fastened by a screw. A terminal part **65** that is provided with a terminal of a wiring for transmission of electric power to the motor and transmission of a control signal is disposed on this cover.

The auxiliary chamber **25** is structured to be in communication with the principal chamber **23** at the opening **22** side of the flange part **21** (the engine **1** side) with respect to the rotor **12**, and also to be in communication with the main discharge part **26**, whereby the opening **22** and the main discharge part **26** are in communication with each other. Thus, the principal chamber **23** opens and closes the communication between the opening **22** and the main discharge part **26** by the main valve **11** that is provided with the rotor **12**. And on the other hand, the auxiliary chamber **25** detours around the main valve **11** so that the opening (admission port) **22** which is in communication with the inside of the water jacket **1***a* of the engine **1** and the main discharge part (exhaust port) **26** may be in communication with each other.

This auxiliary chamber **25** serves as a detour channel **67** that allows the admission port and the exhaust port of the coolant control valve apparatus **10** to be in communication with each other by detouring around the main valve **11**.

The FS valve **40** is disposed in the auxiliary chamber **25** that serves as this detour channel **67**, and opens and closes the detour channel **67** by which the opening **22** side and the main discharge part **26** are in communication with each other. The FS valve **40** is provided with: a valve main body **41** (a secondary valve) that opens and closes the detour channel **67**; a temperature detection medium **42** that includes this valve main body **41** and drives to open and close the valve main body **41** according to a temperature change; and a returning spring **43** that energizes the valve main body **41** toward the open side.

As the temperature detection medium **42**, for example, a thermowax, is used, and also, a thermostat, shape-memory alloy and the like can be adopted, as far as they can open and close the valve at a preset temperature by their displacement according to the temperature. When the temperature becomes higher than the preset temperature (range), the temperature detection medium **42** opens the valve main body **41** so that the opening **22** and the main discharge part **26** may be in communication with each other. When the temperature becomes lower than the preset temperature (range), the temperature detection medium **42** closes the valve main body **41** so as to shield between the opening **22** and the main discharge part **26**. Incidentally, in the temperature detection medium **42**, the thermowax is stored inside a case, and a known mechanism for driving the valve main body **41** corresponding to expansion and contraction of the thermowax is incorporated.

Incidentally, the preset temperature of the FS valve **40** is higher than the above-described preset temperature of the main valve **11** for opening and closing the communication between the opening **22** and the main discharge part **26**. The temperature detection medium **42** operates to open the valve main body **41** of the FS valve **40** when the temperature becomes higher than the preset temperature at which the main valve **11** opens the communication between the opening **22** and the main discharge part **26**.

The returning spring **43** energizes the valve main body **41** toward the open side. If, for example, the temperature detection medium **42** is broken and the valve main body **41** becomes in a state where it can be opened and closed freely, the returning spring **43** opens the valve main body **41**. Thereby, even when the FS valve **40** is not operated, if the valve main body **41** is in a state where it can be opened and closed freely, the valve main body **41** can be opened.

Further, in the auxiliary chamber **25**, the bypass discharge part **27** that is connected to the bypass channel **5** is provided communicating with the inside of the auxiliary chamber **25**. Thus, the actual bypass channel **5** extends from the opening **22** of the flange part **21** of the casing **20** in the coolant control valve apparatus **10**, passes through the part of the principal chamber **23** at the opening **22** side with respect to the rotor **12**, reaches the auxiliary chamber **25** of the casing **20**, and is connected to a tube that is not illustrated and constitutes a main part of the bypass channel **5** from the bypass discharge part **27**, whereby the coolant is sucked by the water pump **2** from the bypass channel **5**.

Therefore, inside the casing **20** of the coolant control valve apparatus **10**, the bypass channel **5** is provided being diverged from the principal chamber **23** that is a part of the main channel **4**, and the detour channel **67** of the auxiliary chamber **25** is disposed in the part where the bypass channel **5** is diverged from the main channel **4**, and then, the temperature detection medium **42** of the FS valve **40** is disposed in the part that is to be the bypass channel **5**.

Thereby, even when the main valve **11** is closed, and the coolant is not flowing in the main channel **4**, the coolant that is flowing in the bypass channel **5** is regularly in contact with the temperature detection medium **42**, so that the coolant which is just flowing out of the water jacket **1***a* of the engine **1** and has a temperature substantially equal to a temperature inside the water jacket **1***a* is in contact with the temperature detection medium **42**, regardless of whether the main valve **11** is opened or closed.

Thus, since the temperature detection medium **42** is regularly in contact with the coolant whose temperature is substantially equal to the temperature inside the water jacket **1***a*, when the temperature of the coolant inside the water jacket **1***a* is increased to the preset temperature or higher, at which the temperature detection medium **42** opens the valve main body **41** from the closed state, the temperature of the temperature detection medium **42** is also increased to the preset temperature or higher by the coolant flowing toward the bypass channel **5**, whereby the valve main body **41** can be opened. Also, in the case where the coolant temperature is decreased, the temperature of the temperature detection medium **42** is similarly decreased to the preset temperature or lower by the coolant flowing toward the bypass channel **5**, whereby the valve main body **41** is closed.

Incidentally, according to the conventional structure, in the case of disposing the FS valve having the temperature detection medium into the coolant control valve apparatus, when the coolant control valve apparatus is in the closed state, all of the coolant in the coolant control valve apparatus is not flowing and is stopped. Thus, the temperature is not transmitted by the flow of the coolant, and heat is transmitted via the casing of the coolant control valve apparatus which is fixed to the water jacket **1***a* and by the coolant that is not flowing therein. Then, the FS valve **40** is operated according to this transmitted heat, so that the operation of the FS valve **40** is delayed from the change of the coolant temperature inside the water jacket **1***a*.

On the other hand, according to this embodiment, the temperature of the coolant inside the water jacket **1***a* is transmitted swiftly to the temperature detection medium **42** of the FS valve **40** by the coolant that is flowing out of the water jacket **1***a* toward the bypass channel **5**, whereby the FS valve **40** can be operated swiftly corresponding to the temperature change of the coolant inside the water jacket **1***a*.

The main discharge part **26** is in communication with the principal chamber **23** which is a part of the main channel **4** as described above and is opened and closed by the main valve **11** having the rotor **12**, and also, is in communication with the auxiliary chamber **25** which is in communication with the detour channel **67** and is opened and closed by the FS valve **40**, thereby discharging the coolant that is flowing out of the water jacket **1***a* via the principal chamber **23** and/or the auxiliary chamber **25** to a tube that constitutes the main channel **4**.

Moreover, the sub discharge part **28** is provided at a position corresponding to the rotor **12** (the main valve **11**) in the principal chamber **23**, and discharge pipes **71** and **72** are opened and closed respectively, according to positional relationships between: openings for the respective discharge pipes **71** and **72** which are formed in an isolation wall between the principal chamber **23** and the sub discharge part **28**; and an opening for the sub discharge part **28** which is formed in the rotor **12** of the main valve **11**.

In such a coolant control valve apparatus **10**, even in a state where, since the main valve **11** is closed, the coolant is not basically flowing in the coolant control valve apparatus **10**, the coolant is regularly flowing in the part of the temperature detection medium **42** due to the bypass channel **5** that is diverged at the part of the temperature detection medium **42** of the FS valve **40** as described above, and the coolant temperature inside the water jacket **1***a* of the engine **1** is transmitted swiftly by this coolant, whereby the FS valve **40** can be opened and closed corresponding to the change of the coolant temperature inside the water jacket.

That is, if, although the coolant temperature inside the water jacket **1***a* reaches the preset temperature at which the main valve **11** opens the main channel **4**, the main channel **4** is not opened due to malfunction of the main valve **11**. And further, the coolant temperature inside the water jacket **1***a* is increased to reach the preset temperature for opening the FS valve **40** The FS valve **40** becomes opened in a short period of time, whereby the temperature control of the coolant inside the water jacket can be stable.

Incidentally, in the above-described embodiment, only the main valve **11** normally controls the flow rate of the coolant in the main channel **4**. But, in addition to the main valve **11**, the FS valve **40** may be normally used for controlling the flow rate. For example, an upper limitation may be added to the preset temperature for opening the main valve **11**, and the main valve **11** may be closed when the coolant temperature reaches the upper limitation of the preset temperature. And further, the FS valve **40** may be opened at a temperature that is substantially equal to this upper limitation of the preset temperature.

Incidentally, the control of the timing for switching between the main valve **11** and the FS valve **40** can be set freely, so that, for example, the opening degree of the main valve **11** may be decreased at a temperature before reaching the upper limitation of the preset temperature, and the FS valve **40** may be opened at this temperature.

In this case, the flow rate of the coolant at lower temperatures is controlled by the main valve **11**, and the flow rate at higher temperatures is controlled by the FS valve. Basically, while the temperature of the coolant is low, for example, at engine starting or the like, the flow rate of the coolant is controlled by opening and closing the main valve **11**. And while the temperature of the coolant in the engine is higher than the preset temperature, for example, during travelling, the main valve **11** is held closed, and the FS valve **40** is opened and closed according to the change of the temperature detection medium **42** by the temperature so as to control the flow rate of the coolant, thereby controlling the coolant temperature. For example, when the coolant temperature is decreased due to a change of an outside air temperature, a change in travelling speed (including an idling time, while the speed is zero) or the like, the FS valve **40** is closed. At this time, the main valve **1** is maintained in a desired state of closing. In this case, after the period of engine starting while the coolant temperature is low, the main valve **11** is maintained closing the main channel **4**, but the sub channels **6***a* and **7***a* are opened and closed by the main valve **11**. In the above-described case, the FS valve **40** functions as a valve for controlling the coolant temperature, and for example, in the coolant control valve apparatus **10**, the main valve **11** functions as a valve for the low temperatures, and the FS valve **40** functions as a valve for the high temperatures.

As described above, by decreasing the working time of the main valve **11**, the lifespan of the main valve **11** can be extended.

REFERENCE SIGNS LIST

1 engine
3 radiator
4 main channel
5 bypass channel
6 heater
6*a* sub channel
7 throttle
7*a* sub channel
10 coolant control valve apparatus
11 main valves (valve)
12 rotor
40 fail-safe valve
41 valve main body
42 temperature detection medium
67 detour channel

The invention claimed is:

1. A coolant control valve apparatus comprising:

a main valve that controls the flow rate of coolant in a main channel of an engine cooling system circulating the coolant between an engine and a radiator;

a detour channel diverging from the main channel as a detour for the coolant from the valve to flow away from the main channel;

a secondary valve moved independently from the main valve to open and close the detour channel; and

a temperature detection medium that drives movement of the secondary valve to open and close the detour channel, and can open and close the secondary valve according to a temperature of the coolant,

wherein the temperature detection medium is disposed in a diverging part between the detour channel and a bypass channel of the engine cooling system directing the coolant leaving the engine to bypass the radiator and return to the engine,

wherein the coolant is regularly flown out of the engine, and the temperature detection medium is in the bypass channel,

wherein the coolant that is flown in the bypass channel is regularly in contact with the temperature detection medium,

wherein the main valve is a rotary valve provided with a rotor and includes a controlling means that controls a rotation angle of the rotor,

wherein the controlling means includes a power transmission mechanism having a gear train, and

wherein the secondary valve is a fail-safe valve that is driven by the temperature detection medium to be opened from a closed state according to a change of a detected temperature, and to be opened when the temperature of the coolant becomes a predetermined temperature or higher.

2. The coolant control valve apparatus according to claim **1**, wherein

the engine cooling system includes at least one sub channel that circulates the coolant between the engine and a device requiring circulation of the coolant and

the main valve can control a flow rate of the coolant in the sub channel.

* * * * *